Report on the PhD thesis manuscript: "Formation and evolution of stellar populations based on the red passive galaxies observed up to the redshift z~1' presented by Malgorzata Siudek

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The work presented in this dissertation by Ms Malgorzata Siudek is based on the data provided by the VIMOS Public Redshift Survey (VIPERS) complemented by the data extracted from the Sloan Digital Survey (SDSS) database. The combination of these two surveys allow the candidate to define an homogeneous sample of passive galaxies defined with similar criteria at redshift z=0 (SDSS) and z=0.7 (VIPERS). The samples thus defined are much larger than the ones used in previous studies. The deep knowledge of the VIPERS survey enables the candidate to extract high quality data that she controls quite well. It results a very convincing analysis of the evolution of the population of red, passive galaxies which goes beyond any previous work on the topic.

The first part of the manuscript (Chapters 1, 2 & 3) is devoted to the general description of the topic and the introduction of key concepts useful for the current study, as well as to the description of the surveys (SDSS and VIPERS) used in this work.
The text is very well documented, with a large corpus of references, also including rather old ones, which is not usual in recent thesis manuscripts. Except some repetitions (for example on the red and blue separation of galaxies in chapter 1 and then again in chapter 2), the text is pleasant to read and well written.
Chapter 1 is a general presentation of the formation and evolution of galaxies and structures. It is a very complex topic with a large amount of recent results, and with ramified sub-topics. The formation of currently red, quiescent objects, involve the past evolution of star forming systems and this chapter deals with the two ones before focusing in the last section (quenching) to objects which stopped their star formation.
The candidate introduces different, related topics: cosmological evolution of the universe from observations of the Cosmic Microwave Background, cosmological models and the detection of few very distant objects. The connection between them and how they impact our understanding of galaxy formation and evolution is not fully obvious in the text. Then comes a classical description of stellar evolution
The section focusing on the processes directly related to galaxy formation and evolution adopts an historical point of view and the development of the last ten years. The downsizing scenario and quenching process which are central to this work are introduced. A mention of the so-called main sequence relating stellar masses and star formation rates in galaxies over a very large range of redshifts would have enriched this general presentation.
The chapter 2 is devoted to the main observational properties of the objects studied in the thesis..

Colour diagrams with the choice of the NUV r K diagnostics and the fundamental plane relations linking dynamical and photometric characteristics. While the fundamental plane relations are quite well introduced together with the recent developments, the link of colours like NUV-r and r-K (or other ones used by other teams) to the star formation history of galaxies should have been more detailed (section 2.1.1).
The SDSS and VIPERS surveys are presented in Chapter 3 with general properties like the coverage, the datasets. A description of physical parameters derived from the VIPERS data is added. The combination of the two surveys results in large datasets of galaxies from z=0 to z~1.

The presentation of the work realised in the thesis starts at Chapter 4 where the selection of red passive galaxies from the VIPERS survey is described. After the of different criteria to separate between early and late-type galaxies (in this chapter and before), the author decides to use the U-V colour with a cut evolving with z, the quality of the selection and the possible contamination is carefully checked, including visual inspection of the individual spectra. Then the comparison sample extracted from the SDSS survey is introduced, with a similar selection based on the U-V colour, after an estimation of the U and V magnitudes by combination of u, g and r SDSS magnitudes.
The selection of the datasets is well described, and well controlled thanks to the careful checks in completeness and contamination. One possible minor issue might be the stellar masses measured with different methods in the SDSS and VIPERS samples. I would have appreciated to see masses measured with the same methods in representative sub-samples of the two datasets. At this stage, the luminosity or mass function of the selected galaxies and the comparison with other published distributions would have been useful for the description of the samples, these quantities are presented in Chapter 10, but in an other context.

The methodology to analyse the data is presented in Chapters 6 to 8. The chapter 5 is short (ends with 5.1 and no 5.2…), and describes the combination of VIPERS spectra (stacking method) to measure average spectral indices which cannot be measured individually. The choice of the spectral indices and their measures are explained in Chapters 6 and 7, the choice of D4000 and Hδ indices for the analysis is well justified: they are classical and well calibrated indices to estimate stellar ages under simple assumptions.
The models used to calculate these quantities are also very classical: stellar models of Bruzual and Charlot (2003), single exponential bursts with very short τ values and fixed metallicity. The exploration of different star formation models and other stellar libraries might have been useful, the issue of the TP-AGBs is mentioned but no calculation is presented. More complex, composite star formation histories may also have an impact, consistency with photometric colours, in particular U-V. The dependence on metallicity is discussed in Chapter 10.

The Fourth part of the manuscript includes the main results of the thesis and starts in Chapter 9 where the evolution of the UV-V colour-mass relation with redshift is presented. The analysis confirms previous results and extends the analysis to both lower and larger stellar masses. Thanks to its large coverage, VIPERS extends previous studies based on the zCOSMOS spectroscopic survey to higher masses and lower redshift. The slope of the colour-mass relation does not really depend on redshift. The relation is also found flatter than the one found with SDSS galaxies at z=0, but any firm conclusion needs to check the process of mass determination in both surveys.

The detailed analysis of the Hδ and D4000 evolution is quite convincing: the values on these indices found for the transition mass between active and passive galaxies define an homogeneous sequence of high mass quiescent objects when the galaxies with spectral indices corresponding to systems less massive than expected for passive galaxies are convincingly found to form a more inhomogeneous sample with a larger dispersion in Hδ and D4000.
I am slightly less convinced by the determination of the age of the main stellar population of these objects. Their 'zform' redshift is obtained with single burst models when the history of these objects is expected to be more complex. While the retrieved values have a relative meaning for comparison between objects, the ages obtained in this work can be considered as a first, model-dependent guess. The simultaneous use of the two spectral indices together with colours to be compared to more complex models may help to either refine the measurements or put more realistic uncertainties. The role of the metallicity is well described, and adds even more (realistic) uncertainties to the results.

The two last chapters of the thesis (11 & 12) present a machine learning algorithm to define galaxy classes, based on multidimensional criteria combining photometric and redshift information. The efficiency of the method is checked for the VIPERS galaxies by further analysing their spectroscopic and morphological properties. With the collection of huge quantities of data from the large photometric and spectroscopic surveys, the need for automatic classifications of the detected sources based on machine learning methods is obvious. The method presented in this work is very promising and a paper is in preparation on this specific work.

The work reported in this PhD dissertation is of very high quality and represents a significant progress in the study of the population of red passive galaxies from past to current time. The quality of the data analysis, the large statistics and the careful use of various indices lead to very robust results which nicely confirm and extend previous, more limited analyses. The variation of several stellar age indices with stellar masses over redshifts ranging from 0 to ~1 asserts the downsizing process for the population of red galaxies, with massive objects exhibiting older stellar populations than low-mass, red galaxies. The observational quantities measured in these studies, average values and dispersion, will certainly bring strong constraints to models of galaxy formation.
Last but not least, the expertise developed by the candidate in automatic classification of galaxies has a very promising future in observational cosmology with increasing large surveys.

To conclude, as far as I can seed from the dissertation, the work of the candidate meets all the criteria that a PhD thesis should satisfy. Ms Magorzata Siurek has a very solid knowledge about extragalactic astrophysics and fully masters the concepts and tools used in her work. I am totally in favour of the defense of her PhD thesis.

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